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ABSTRACT

An introductory course for the engineering technologies may be offered for secondary school credit, two-year college credit, or combined secondary and college credit to provide a necessary bridge between high school and college. The course curriculum combines an overview of the different engineering technologies with some actual knowledge and skills needed to master later coursework in the technologies. Course instructors must be carefully selected. They must be experienced technical-level instructors, be experienced in the real-world needs of industry, and be comfortable discussing philosophical-social concepts and not simply math-science concepts. The course should: (1) present career planning information that clearly defines the responsibilities of the various disciplines; (2) integrate people skills; (3) provide information on professional societies; (4) address applications requiring mathematics rather than present a complete treatment of mathematics; (5) emphasize the importance of the basic rules of algebra; (6) introduce engineering applications involving trigonometry; (7) present conversion; and (8) teach the international system of measurement. At least one hands-on laboratory experience is recommended. The course also provides an opportunity to establish standardized reporting and to introduce the students to computer application programs. (YLB)

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IMPLEMENTING

an

INTRODUCTORY COURSE

to the

ENGINEERING TECHNOLOGIES

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ABSTRACT

This paper describes an introductory course for the engineering technologies that may be offered for secondary school credit, two-year college credit, or combined secondary and college credit. The course provides a necessary bridge between high-school and college. The need for a tech-prep/associate-degree program is described in Dr. Dale Parnell's work, *The Neglected Majority*, 1985.

The curriculum for the introductory course will be described. The course curriculum combines an overview of the different engineering technologies, with some actual knowledge and skills needed to successfully master later coursework in the technologies. Can so varied a menu be effectively instructed in a typical three to five credit hour course? The answer is "yes," but only by recognizing the need for well-selected, concrete, real-life examples, that integrate the skills and knowledge necessary to succeed in the engineering technologies.

The presentation will suggest ideas for successfully instructing an Introduction to Engineering Technology course. How does one instruct a generic course attended by students possessing extremely divergent backgrounds? Which instructors are best suited to instruct such a course? From the author's personal experience, these and other questions will be addressed.

The course enables students to successfully prepare for careers in the engineering technologies. Tech-prep students from vocational, as well as general preparatory, high-school programs benefit. Non-traditional students wishing to return to school after many years also benefit. More students means more qualified engineering technicians and technologists to provide quality products and the competitive edge U.S. Industry requires to compete with foreign manufacturers.

IMPLEMENTING AN INTRODUCTORY COURSE TO THE ENGINEERING TECHNOLOGIES -

the need for such a course, a recommended curriculum, and selected presentation suggestions

An introduction to any field of endeavor should accomplish at least two objectives:

1. establish an overview or "big picture", so students may better understand the career field they are considering, and make an informed decision as to what specialization (what technology in this case) they wish to pursue.
2. build a functional base of skills and knowledge, which allows the student to successfully pursue an education in the chosen specialization.

Additional objectives may be accomplished for the administration and faculty of the engineering technologies.

1. provide a period of orientation for new students,
2. bring a quite diverse group of people (traditional students may have never seen an industrial operation, while non-traditional students may lack crucial basic knowledge) into the world of technology, so they may demonstrate a minimum level of competence that assures their understanding of later course material.
3. create a sense of belonging to -- and pride in being a part of -- the exciting world of the implementors.

The proposed course may also provide engineering technology departments an opportunity to assess incoming students. Comprehensive, standardized final exam averages may be charted over time to discover trends in students' needs and abilities.

An "introductory course" may provide curriculum to satisfy the emerging needs of "tech-prep" programs. In other words, students could obtain college credit while completing their high-school programs. Dr. Dale Parnell, President of the American Association of Community and Junior Colleges, suggests in his book, *The Neglected Majority* , the need to build bridges between high schools and higher education. Over fifty-percent of our students are not currently served by vocational education or a college-prep program. Better communication between secondary and higher education will allow this neglected majority to enter a tech-prep program before leaving high school, and continue on to obtain a technical education.

The course curriculum to be presented is not simply an idea, but is reality. The course has been instructed for more than ten years to over 600 students at Central Ohio Technical College. The curriculum has been presented by myself, other full-time instructors, and by adjunct faculty.

Interestingly, the need for such a course was first brought to light in an advisory committee meeting in the late 1970s. At that meeting a student on the advisory committee noted that he had changed majors at the end of the first year of study, after he had found that he really wanted to be an Industrial Engineering Technician rather than an Electronic Engineering Technician.

Convinced that some "bridge" was needed to allow the incoming student to best adjust to and understand the varied world of the engineering technologies, the college decided to bring the new course into the curriculum. Course implementation at the time (1978) was difficult for several reasons. Two major reasons existed:

(1) technical instructors in the various technologies felt there was "no room" for such a course in their quite full curriculums, and

(2) there was not a suitable text available.

The first concern, "no room for such a course," was answered, by the faculty realizing that certain skills were lacking in all technologies. Those skills were to be addressed in the new course. Students in courses following the proposed "intro course", being better prepared, could more efficiently receive instruction in those courses.

The second concern, that of a suitable engineering technology text was more difficult to address. Introduction to Engineering textbooks were available, but found to be written for students who received a high school, college prep/baccalaureate degree curriculum; and not written for Dale Parnell's *Neglected Majority*.

In attempting to address the needs for a suitable text, faculty at Central Ohio Technical College eventually co-authored a textbook, *Prep High Tech*, in 1984 that was used for five years in our Introduction to Engineering classes. The text has also been used in at least six other colleges. My new text, *Introduction to Engineering Technologies*, was published by Macmillan Publishing in the spring of this year (March, 1990).

It has been more than ten years since the introductory course was implemented. Course evaluations have been favorable. Some examples of student comments on evaluations are as follows: This course made me think a lot more about what I want out of life. -- If it had not been for this course, I could not have understood my other courses. -- I felt very much at ease in this class compared to others. -- The calculator skills I have learned are helping me in my other classes. -- Very informative on dimensional analysis and conversion of units. -- Seems like the material should be taught in other courses but never is. -- This course was extremely helpful in providing a better understanding of the [engineering] technologies available.

Pretest/Posttest information has been encouraging. Twenty multiple-choice questions, designed to test for understanding of elementary course material, have shown the posttest group to be different with a confidence level of 99%.

Correlation of final grades in a co-requisite algebra course with the final grade in the introductory course, revealed a moderately strong correlation. An extremely interesting finding was that the low - "C" -and - better students in the Algebra course, showed a weaker correlation of algebra course grades with introductory course grades. This finding reveals that a moderate level of mathematics knowledge is necessary to be successful in the introductory course, but a knowledge of mathematics beyond this moderate level does not, necessarily, result in better skills in solving engineering technology problems.

A possible course structure may be best described by an example of a course syllabus. The following syllabus has been used successfully in Introduction to Engineering Technology classes.

SUGGESTED COURSE SYLLABUS

REQUIRED MATERIALS: A multifunction (at least 32 functions) scientific calculator. The text, *Introduction to Engineering Technology.* At least one computer disk.

COURSE DESCRIPTION: Today's engineering and technology fields are explored and the varying roles of engineering technicians are discussed. Topics of study include: the concepts and terminologies used in engineering, applied mathematics, use of scientific calculators, problem solving techniques in classroom and laboratory, and the units and dimensions used in business and industry. Students are introduced to the personal computer and computer application software.

PREREQUISITES: Demonstrated competence (by entrance exam) in basic arithmetic, with a knowledge of signed numbers, or concurrent enrollment in technical mathematics.

ASSIGNMENTS

WEEK 1	Engineering Technology as a Career
WEEK 2	Survival Skills in College (Quiz 1)
WEEK 3	The Scientific Calculator

WEEK 4	Units and Dimensions
WEEK 5	Review of Calculator/Units and Dimensions (Quiz 2)
WEEK 6	Geometry/Dimensional Laboratory
WEEK 7	Trigonometry (Quiz 3)
WEEK 8	Formal Laboratory (Force Vectors)
WEEK 9	The Personal Computer (Quiz 4)
WEEK 10	Using Computer Software
WEEK 11	Your Future in Technology (Final Exam)

EVALUATION POLICY:

25% Homework
20% Laboratory Reports
40% Four Quizzes
15% Final Exam

All assignments are due at the beginning of the following week's class meeting. The lowest homework grade will be dropped. The instructor suggests that students complete assigned homework as soon as possible after each class meeting.

Students must notify the instructor of an absence prior to a quiz or exam in order to be considered for a make-up.

Course instructors must be carefully selected. The most important prerequisite is that they are experienced technical level instructors. Inexperienced instructors will find it difficult to be sensitive to the needs of beginning technical students. Instructors need not be an expert in all engineering fields, but should be experienced in the real-world needs of industry. Finally, the instructor should be comfortable discussing philosophical-social concepts, not simply math-science concepts.

Course instructors should be aware of what the students do not know. For instance, they may not know that odd-numbered answers are found in the back of the text and it is "O.K." to use them in checking the accuracy of their homework. They may not know the responsibilities of technical workers in the major engineering disciplines: What does a mechanical engineering technician do? Can a Civil Engineering Technician design a bridge, or does that require a Professional Engineer, P.E.? Simple calculator skills must be addressed, such as how to enter a number into

the calculator using the exponent (power of ten) key.

How do we best present the necessary material in an introductory course? Some suggestions follow.

Presenting career planning information is enhanced by clearly defining the responsibilities of the various disciplines. What are the differences between engineers and engineering technicians? What do the technicians - the implementors - give to our society? Frank discussions of salary information and opportunities for upward mobility are also important to the student. Figures One and Two may be presented as the elements of career components are discussed.

Technicians and Technologists require skills for working with others -- people skills. Participative management practices, such as quality circles, demand good communication and problem solving skills. The need for these skills should be integrated throughout the course. Methods for addressing communication and problem solving skills may be addressed by students participating in group problem solving exercises. The author has used NASA's "Moon Voyager Problem" successfully in allowing students to experience the exigencies of group problem solving during an emergency. (The problem is to agree, in a group process, how to prioritize a list of items to take from their (the groups) damaged ship on the moon to the "Mother" ship that is located 200 miles away.)

This course may offer the only opportunity in the student's technical education to receive information on professional societies. Active, voluntary participation in professional associations is one way to increase a students' understanding of the needs of society and how he or she may best contribute. Technical instructors should consider the formation of student

chapters to enhance professional involvement, which engenders a feeling of belonging and results in increased student retention. At Central Ohio Technical College we have a very successful Instrument Society of America (ISA) Student Section. An adequate number of student members (difficult to achieve in a two-year college) are successfully recruited in the Introduction to Engineering Technology course.

The introductory course is not the place to present a complete treatment of the mathematics. Rather than teaching mathematics, applications requiring mathematics should be addressed. Working through engineering applications will motivate students to want to learn the material presented in their mathematics classes. Some prior experience with signed numbers must be assumed in order for students to understand the calculator and the use of powers of ten. Therefore, the students enrolled should have had the equivalent of one-year of high school algebra or be enrolled concurrently in an algebra course. Students requiring remedial mathematics should be advised to enroll in the introductory course later in their studies.

Although some experience with signed numbers is expected, a very limited algebra competency is assumed. Where algebra is used, for instance in unit conversion, solution steps should be carefully laid out and explanations given. The instructor should emphasize the importance of the basic rules of algebra (see Figure 3).

Trigonometry is a most important problem solving tool in the engineering technologies. The trigonometry of the right triangle may be presented, but only by using the first quadrant of the X-Y coordinate system. An early introduction to engineering applications involving the right triangle will motivate students to better understand their trigonometry course that usually follows in the second quarter; allowing them "to better see the forest, not just the trees." Mnemonic devices may be used to aid the student in rearranging the sine, cosine, and tangent

functions (see Figure 4). A course in trigonometry is not prerequisite to understanding introductory course material.

Converting units and dimensional analysis is crucial to competent problem solving in science courses such as applied physics. A four-step conversion process may be presented to allow students to easily convert units within the English System (U.S. Customary System), within the metric system (principally S.I. System), and between the two systems (see Figure 5). The author has found the four-step conversion method to be maximally effective in training students to consistently and correctly perform unit conversion.

Most importantly, technicians should be trained and educated to understand the international system (SI) of measurement and its unique conventions. A specific example is to eliminate the use of the comma to separate groups of three numbers from the decimal point. Confusion results, with the use of the comma, because some European communities use the comma as a decimal point. The appropriate use of the SI is critical to U.S. competitiveness in world markets.

At least one "hands-on" laboratory experience is suggested. The laboratory represents a major portion of the technician's and technologist's education. The laboratory also offers a chance for faculty to address the need for quality report writing.

Quality technical reporting is one of the most important factors in upward mobility for technicians and technologists. The introductory course offers your engineering technology department an opportunity to establish standardized reporting across the engineering technology curriculum. More importantly, the engineering department shows "up front" that it supports the efforts of the general studies faculty. Without such support, their efforts are minimized.

A laboratory safety lecture should be given before laboratory. A laboratory safety quiz after the lecture provides documentation that safety was adequately addressed. This "documented quiz" could decrease instructor liability in all technical programs at your institution.

The technical student will benefit from a "big picture" of the world of the computer; along with experience with frequently used (and friendly) application programs. The introductory course offers an opportunity for the student to use application programs such as word processing and spreadsheets, before being introduced to programming later in their curriculum. Familiarization with word processing may benefit the incoming student in writing for communication classes. Spreadsheets are perhaps most important to engineering students, for they represent the most frequently used software in industry.

Colleges possessing appropriate hardware may offer an early hands-on opportunity for students. At Central Ohio Technical College our "open-computer laboratory" is available for all introductory engineering technology classes. Students learn to use powerful minicomputers, with hard disks and excellent wordprocessing and spreadsheet software, in the first quarter of their studies at the college.

While presenting the introductory course material, instructors should take time to give clear and concise, step-by-step explanations of selected problem solving examples. Instructors will find students are not bored by discussing examples in detail. Related applications from the instructor's experience should be introduced. The opportunity for an instructor to share his or her industrial experience is important to students. The efficacy of instructor-student interaction cannot be overemphasized in a first-term, introductory course.

The Introduction to Engineering Technology course recommended, then, will satisfy at least two major needs for education. The need for improved articulation and the need for a suitable introduction to the varied subject areas that make up the engineering technologies. In a recent letter to me, Dr. Parnell stated:

> "You are right on target in your comment that improved articulation between the vocational/technical schools and community colleges will help develop a world class work force. Educators must give greater attention to continuity in learning at all levels. I firmly believe what I wrote in my book, Dateline 2000, that by working together, different systems and different academic disciplines can produce results that are greater that the sum of the parts."

I must, personally, state how strongly I feel about the need for some type of "big-picture" understanding on the part of our students. The world is rapidly changing. Technicians trained in a single engineering discipline and not exposed to "what engineering technology is all about," will later - or sooner than later - in their careers, be at a serious disadvantage. Can we do any less for our future engineering technologists, than to give them a solid, broad-based beginning in a career that fills so much of their life?

I wish you success in your endeavors to contribute to a "great beginning" for aspiring engineering technicians and/or technologists. You are responsible for the high quality technical education that will provide needed technologists for tomorrow. You must do it, for the world needs qualified technical employees to fulfill the promise of "a good life for all."

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THE INDUSTRIAL TEAM

Duties of Position -- Theory and Application Ratio -- Education Required

Duties	% Theory	% Applied	Education
1. Scientist -- Hypothesizes and verifies laws of nature.	90%	10%	five to seven years of college
2. Engineer -- Designs equipment and processes	70%	30%	four or five years of college
3. Technologist -- Makes design prototype -- suggests redesign or modification -- acts as manufacturing engineer.	60%	40%	four years of college
4. Technician -- tests and troubleshoots prototypes and hardware/software in actual production use. Acts as manufacturing supervisor.	50%	50%	two years of college
5. Skilled Worker (craftsman) -- Produces parts (e.g. holding fixtures) from completed designs. Installs and runs hardware.	20%	80%	four years of on-the-job training or vocational high school

3. The Industrial Team—Duties and Education

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Figure 1

THE ASSOCIATE DEGREE

1. ASSOCIATE IN ARTS OR SCIENCE
   PREPARES STUDENT TO TRANSFER TO BACCALAUREATE DEGREE PROGRAM

2. ASSOCIATE OF SCIENCE IN ENGINEERING TECHNOLOGY
   DESIGNED TO LEAD THE INDIVIDUAL TO EMPLOYMENT IN A SPECIFIC CAREER

3. THE ASSOCIATE DEGREE PROGRAM POSSESSES A CLEAR CURRICULUM, THAT REQUIRES THE STUDENT TO DEMONSTRATE PROFICIENCY IN THE USE OF LANGUAGE AND COMPUTATION.

4. EMPLOYERS RECOGNIZE THE ASSOCIATE DEGREE AS THE BEST INDICATION THAT A GRADUATE HAS OBTAINED NECESSARY KNOWLEDGE AND SKILLS TO PERFORM SUCCESFULLY IN BUSINESS AND INDUSTRY.

5. EVALUATIVE CRITERIA
   - PROVIDES THE STUDENT WITH APPROPRIATE COMPETENCIES THROUGH THE USE OF ADVISORY COMMITTEES.
   - PROVIDES THE STUDENT WITH A FOUNDATION IN GENERAL EDUCATION, RESULTING IN UPWARD MOBILITY.
   - HAS REGIONAL ACCREDITATION

4. The Associate Degree

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Figure 2

ALGEBRAIC MULTIPLICATION AND DIVISION

If the signs of the two numbers are alike the result is positive. If the signs are opposite the result is negative.

Examples: $(-2) \times (-3) = 6$ and $(2) \div (4) = 0.5$

$(6) \times (-2) = -12$ and $(-12) \div (3) = -4$

RULES OF EXPONENTS

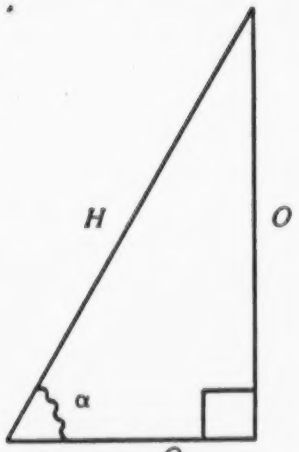
rule	example
$a^0 = 1$	(any base to the zero power is one)
$a^x \times a^y = a^{x+y}$	$3^2 \times 3^4 = 3^6$
$a^x \div a^y = a^{x-y}$	$3^2 \div 3^4 = 3^{-2}$
$a^{-x} = \frac{1}{a^x}$	$3^{-2} = \frac{1}{3^2} = 0.111$
$(a^x)^y = a^{xy}$	$(3^2)^4 = 3^8$
$\left(\frac{a^x}{b^z}\right)^y = \frac{a^{xy}}{b^{zy}}$	$\left(\frac{2^2}{3^3}\right)^4 = \frac{2^8}{3^{12}}$
$\sqrt[y]{a^x} = a^{x/y}$	$\sqrt[3]{3^2} = 3^{2/3}$

CROSS MULTIPLICATION

$$\frac{a}{b} = \frac{x}{y} \quad ; \; ay = bx$$

Cross multiplication only works for monomials (no + and - signs). Factors may be moved across the equal sign by moving them: (1) from numerator to denominator, or (2) from denominator to numerator.

Figure 3

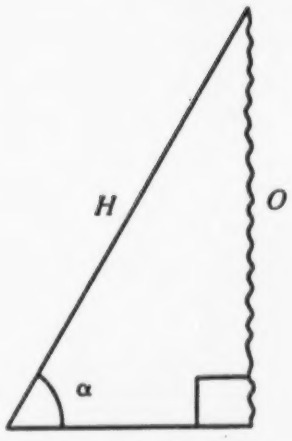


$\sin\theta = \frac{O}{H}$

4 ÷ 5 = 0.8 $\sin^{-1}$

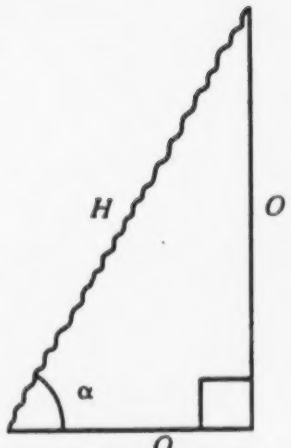
53.1°

A



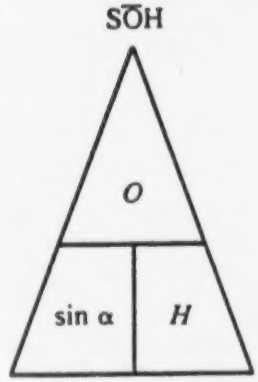
$O = H \sin\theta$

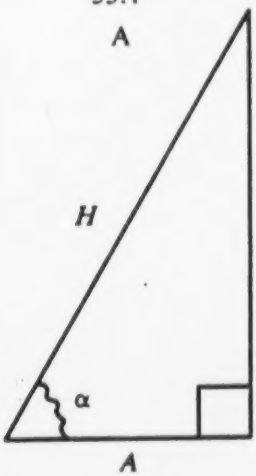
B



$H = \frac{O}{\sin\theta}$

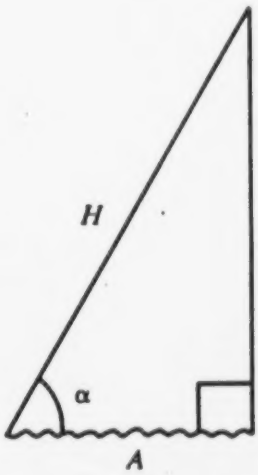
C





$\cos\theta = \frac{A}{H}$

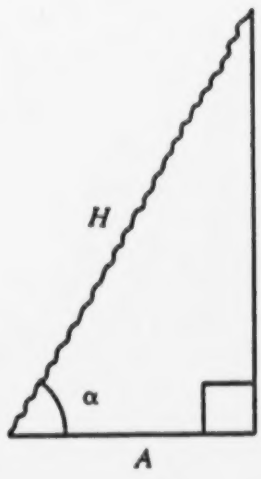
D



$A = H \cos\theta$

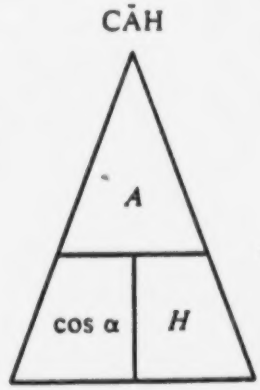
5 × 53.1 cos = 3

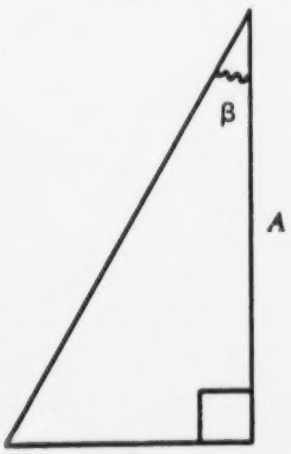
E



$H = \frac{A}{\cos\theta}$

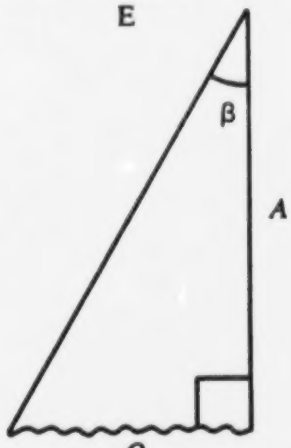
F





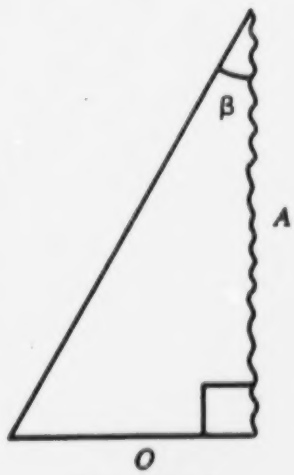
$\tan\theta = \frac{O}{A}$

G



$O = A \tan\theta$

H



$A = O/\tan\theta$

3 ÷ 36.9 tan = 4

I

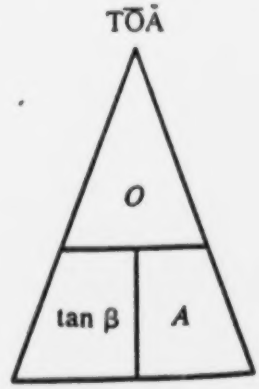


Figure 4

EXAMPLE 4.11. **The length of an Olympic track is 400 meters. Convert this distance to yards (the units used in the U.S.).**

Solution: Using the four step approach listed above:

$$\text{Step 1}: \frac{400\text{ m}}{1} \times \frac{\quad}{\quad} = ?\ \text{yd}$$

$$\text{Step 2}: \frac{400\text{ m}}{1} \times \frac{\text{yd}}{\text{m}} = ?\ \text{yd}$$

$$\text{Step 3}: \frac{400\text{ m}}{1} \times \frac{1\text{ yd}}{0.9144\text{ m}} = ?\ \text{yd}$$

$$\text{Step 4}: \frac{400\text{ m}}{1} \times \frac{1\text{ yd}}{0.9144\text{ m}} = 437\text{ yd}$$

The 400 meter track is very close to the length of the quarter- mile track used in the U.S.

30 011.079 854

not

30,011.079,854

Figure 5